# Final Report for Grant NAG5-4154

## "A SPDS Node to Support the Systematic Interpretation of Cosmic Ray Data"

The purpose of this project was to establish and maintain a Space Physics Data System (SPDS) node that supports the analysis and interpretation of current and future galactic cosmic ray (GCR) measurements by 1) providing on-line databases relevant to GCR propagation studies, 2) providing other on-line services, such as anonymous FTP access, mail list service and pointers to e-mail address books, to support the cosmic ray community, 3) providing a mechanism for those in the community who might wish to submit similar contributions for public access, 4) maintaining the node to assure that the databases remain current, and 5) investigating other possibilities, such as CD-ROM, for public dissemination of the data products.

Shortly after the original grant to support these activities was established at Louisiana State University a detailed study of alternate choices for the node hardware was initiated. The chosen hardware was an Apple Workgroup Server 9150/120 consisting of a 120 MHz PowerPC 601 processor, 32 MB of memory, two 1 GB disks and one 2 GB disk. This hardware was ordered and installed and has been operating reliably ever since.

A preliminary version of the database server was available during the first year effort and was used as part of the very successful SPDS demonstration during the Rome, Italy International Cosmic Ray Conference. For this server version we were able to establish the html and anonymous FTP server software, develop a Web page structure which can be easily modified to include new items, provide an on-line database of charge changing total cross sections, include the cross section prediction software of Silberberg & Tsao as well as Webber, Kish and Schrier for download access, and provide an on-line bibliography of the cross section measurement references by the Transport Collaboration. The preliminary version of this SPDS Cosmic Ray node was examined by members of the C&H SPDS committee and returned comments were used to refine the implementation.

During the second year several improvements were made. First, connectivity with the server was significantly enhanced with the installation of a NASA Science Internet (NSI) multiprotocol T1 link. All of the T1 hardware (router, CSU/DSU, LARS) physically resides on the same building floor as the server and is directly connected to the local LAN. Thus, all in-bound and out-bound connections to the server go directly to the NSI backbone at MSFC and avoid on-campus bottle necks. Other improvements in the server included an operating system upgrade, an increase in the amount of real memory and installation of the Open Transport network protocol stack. This combination of upgrades improved the server stability, increased the capacity of the machine, and improved the TCP/IP throughput. We also installed e-mail listserver software which is designed to automate distribution, forwarding and archiving of e-mail messages. Using this software we established an e-mail distribution list for the Cosmic and Heliospheric SPDS group.

The primary focus of the second year effort, however, was to generate a searchable nuclear interaction cross section database that is accessible from the Web. This effort proceeded in two parts. The first part included reviewing the existing cross section database, which previously existed mostly on hardcopy, verifying the data values with the literature references, establishing a computer readable file of the verified cross sections and providing dataset documentation. This data review continued into the third year. To date more than 2,700 individual cross section values have been verified and entered into the database. Further, the dataset now includes almost 600 very recent cross section measurements provided by the Transport group. This provides a substantial dataset containing the most recent and most reliable measurements obtained from the literature.

The second part of the effort included establishing the Web interface to the cross section database. This effort was considerably more difficult than we had initially anticipated and caused a significant delay in developing the interface. Our initial approach was to use commercially available software for the database server, Butler SQL, for the query generator, Butler Client, and for the CGI component, Tango. After several months of effort this system proved to be exceeding complex, compatibility issues were common, and certain key functionality (such as the ability to generate on-the-fly plots) were not available. Thus, this approach was abandoned in favor of writing our own CGI programs.

We are now using MacPerl, which is a port of UNIX Perl to the Macintosh platform, to integrate the database file with the Webstar http server. We have developed a CGI script that takes search keywords from a html form, searches an ascii file containing the cross section data for a match, and returns the results as an html page. Keywords which are left blank on the form are treated as "wild cards", so groups of cross section values can be easily located. This CGI script also outputs the search results to a separate ascii file, which can be used as input to a plotting package or downloaded via FTP.

During the third year effort we completed the "fine tuning" of the cross section search script and installed it on the server. The user can now select any combination of beam charge, beam mass, beam energy, target charge, target mass, product charge, product mass and/or reference number and the appropriate set of nuclear interaction cross sections satisfying the selection criteria will be displayed on the users browser. At this point the user can save the displayed data to a file on his personal machine for later reference or plotting.

Also available through this interface are the references used to construct the database. In particular, each cross section entry has a reference number keyword, so that the user can refer back to the original literature if further information is needed. We have also scanned the first page of each reference and will link these images to the reference literature listing. This provides the user with an abstract of the paper and other details without the need to locate the reference. We have also experimented with on-line publication and distribution of research papers by providing PostScript versions of a few of the Transport Collaboration papers. More such entries will be provided at time and resources permit.

Other resources are also available to the cosmic ray researcher through this node. For example, we are the main distribution site for the semi-empirical cross section calculation code authored by Silberberg and Tsao. We also distribute the Webber, Kish and Schrier parametric cross section calculation program. Both of these codes are widely used in the scientific community to provide calculated values of nuclear interaction cross sections that have yet to be (or may never be) measured. Thus, the distribution of these programs complements the cross section measurement database. Over the course of this project the Silberberg and Tsao has been updated several times, partial as a result of the new cross section being made available through the database. We have kept each update on-line and clearly marked with the date we received the code. In this way, a user can easily determine if he has the most recent program and can track any changes he sees in the calculated results.

We have also established a database of galactic cosmic ray (GCR) flux measurements. Again we have searched the available literature to locate appropriate references, from which we obtained the measurements. To date, this database contains close to 950 cosmic ray measurements covering the charge range from H to Ni and the energy range from about 10 MeV/nucleon to >1 TeV/nucleon. As time and resources permit we will develop and install a data search script for the GCR measurement database using the model established for the cross section database search.

Finally, during this last year we have purchased a CD-R drive unit that incorporates dedicated hard disks and have used this unit to make copies of the SPDS node files. One problem

with CD-R drives is that they must write in a streaming mode and any interruptions can ruin the disk. The advantage of the unit we purchased is that data can be copied to the dedicated hard disk and CD-Rs are then made directly from the hard disk images. This avoids the interrupt problem. With this unit we will be able to easily satisfy any requests for personal copies of the cross section or GCR measurement data.

The Cosmic Ray Propagation and Nuclear Cross Section Data (Cosmic Ray) SPDS node has been operating successfully for several years and the main entry page can be found at URL http://spdsch.phys.lsu.edu/. During this time usage has grown from 156 files transferred per month by 18 unique sites (during 8/95) to a peak in 1997 of more that 4,300 files per month from 2747 unique sites. Almost half of the unique sites which download files from the node are included in either the .net, .com or .org zones. If one neglects these zones, then approximately 45% of "hits" originate from the EDU domain, 12% from the GOV domain and 43% from nodes outside of the U.S.

Even through this particular project has been terminated, we will continue to maintain and, if possible, expand the capability and resources available through the SPDS node. We have received a number of comments from the community about the node and the general view is that the data being served will continue to be of use to the Cosmic Ray community for many years to come.